ISSN 2250-3153

# Modern Construction and Rehabilitation Techniques

**Anshu Rajput, Divyanshu Pandey**

Civil Department, SRM University

***Abstract-*** The pre-engineered steel building system construction has great advantages to the single storey buildings, practical and efficient alternative to conventional buildings, the System representing one central model within multiple disciplines. Pre-engineered building creates and maintains in real time multidimensional, data rich views through a project support is currently being implemented by Staad pro software packages for design and engineering.

***Index Terms***- Pre-engineered building, STAAD pro, Harmonic Load Generator, and Crane System**.**

## I. Introduction

A tall steel building is not more in the total number of tall steel structures that are built around the world. A large steel structures being built are only single storey buildings for industrial purpose. Secondary structural members span the distance between the primary building frames of metal building systems. They play a complex role that extends beyond supporting roof and wall covering and carrying exterior loads to main frames. Secondary structurals, as these members are sometimes called, may serve as flange bracing for primary framing and may function as a part of the building's lateral load–resisting system. Roof secondary members, known as purlins, often form an essential part of horizontal roof diaphragms; wall secondary members, known as girts, are frequently found in wall bracing assemblies. The majority of steel structures being built are only low-rise buildings, which are generally of one storey only. Industrial buildings, a sub-set of low-rise buildings are normally used for steel plants, automobile industries, light, utility and process industries, thermal power stations, warehouses, assembly plants, storage, garages, small scale industries, etc. These buildings require large column free areas. Hence interior columns, walls and partitions are often eliminated or kept to a minimum. Most of these buildings may require adequate headroom for use of an overhead traveling crane. A third type of secondary framing, known by the names of eave strut, eave purlin, or eave girt, acts as part purlin and part girt—its top flange supports roof panels, its web, wall siding. Girts, purlins, and eave struts exhibit similar structural behavior.

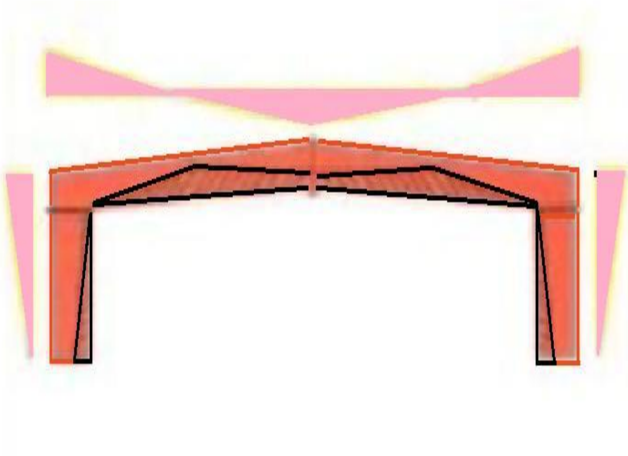
## II. PRE-ENGINEEERED BUILDINGS

The scientific-sounding term pre-engineered buildings came into being in the 1960s. The buildings were ―pre-engineered‖ because, like their ancestors, they relied upon standard engineering designs for a limited number of off-the-shelf configurations. Several factors made this period significant for the history of metal buildings. First, the improving technology was constantly expanding the maximum clear-span capabilities of metal buildings. The first rigid-frame buildings introduced in the late 1940s could span only 40 ft. In a few years, 50-, 60-, and 70-ft buildings became possible. By the late 1950s, rigid frames with 100-ft spans were made; ribbed metal panels became available, allowing the buildings to look different from the old tired corrugated appearance. Third, collared panels were introduced by Strand-Steel Corp. in the early 1960s, permitting some design individuality. At about the same time, continuous span cold-formed Z purlins were invented (also by Strand-Steel), the first factory-insulated panels were developed by Butler, and the first UL-approved metal roof appeared on the market.1st And last, but not least, the first computer-designed metal buildings also made their debut in the early 1960s. With the advent of computerization, the design possibilities became almost limitless. All these factors combined to produce a new metal-building boom in the late 1950s and early 1960s. As long as the purchaser could be restricted to standard designs, the buildings could be properly called pre-engineered. Once the industry started to offer custom-designed metal buildings to fill the particular needs of each client, the name pre-engineered building became somewhat of a misnomer. In addition, this term was uncomfortably close to, and easily confused with, the unsophisticated prefabricated buildings, with which the new industry did not want to be associated. Despite the fact that the term pre-engineered buildings is still widely used, and will be often found even in this book, the industry now prefers to call its product metal b2.

### A. *PRE-ENGINEERED BUILDINGS BY STAAD Pro*

Research Engineers International introduces the next generation of REI's flagship product, Staad pro, the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user-friendly, visualization tools, powerful analysis and design facilities and seamless integration to several Pre-Engineered Buildings modelling and design.

Shape of Pre-Engineered Buildings as shown in (Fig; 1 & Fig; 2) calculates geometric section properties, like



**Fig; 1. Bending Moment Diagram from STAAD. Pro**

area, moment of inertia, etc. It handles multiple materials and composite sections. Shape of Pre-Engineered Buildings also performs advanced stress analysis, cracked analysis, and calculates the strength of Steel sections.Pre Engineered Building frames are normally tapered and often have flanges and webs of variable thickness along the individual members. The frame geometry matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure.

## III. STAAD.Pro Procedure for Pre-Engineered Buildings Overview

- "Concurrent Engineering" based user environment for model development, analysis, design, visualization and verification.
- Object-oriented intuitive 2D/3D graphic model generation.
- Pull down menus, floating toolbars, and tool tip help.
- Flexible Zoom and multiple views.
- Isometric and perspective views 3D shapes.
- Built-in Command File Editor.
- Simple Command Language.
- Graphics/Text input generation.
- State-of-the-art Graphical Pre and Post Processor.
- Joint, Member/Element, Mesh Generation with flexible user-controlled numbering.
- FPS, Metric or SI units.
- Presentation quality printer plots of Geometry and Results as part of run output.
- Compatible with Win95/98/NT
- GRAPHICS ENVIRONMENT:
- Model Generation
- Interactive Menu-driven Model Generation with simultaneous 3D display.
- 2D and 3D Graphic Generation using rectangular or polar coordinate systems.
- Segments of repetitive geometry may be used to generate complex structural models.
- Generate Copy, Repeat, Mirror, Pivot, etc. or quick and easy geometry generation.
- Quick/easy mesh generation.
- Comprehensive graphics editing.
- Graphical Specification and Display of Properties, Loadings, Supports, Orientations.
- Import AutoCAD DXF files
- Access to Text Editor.

*B.Model Verification*

- 2D/3D drawings on screen as well as on plotter/printer.
- Full 3D shapes for Frames, Elements.
- Sectional views or views with listed members only.
- Isometric or any rotations for full 3D viewing.
- Display of Properties, Loadings, Supports, Orientations, Joint/Member numbering, Dimensions, Hidden line removed, etc.
- Plot manipulation according to the size, rotation, viewing origin and distance.

*C.STRUCTURAL ANALYSIS AND DESIGN*

STAAD.Pro may be utilized for analyzing and designing practically for the Pre-Engineered Buildings. implements the Bending Moment, Axial Forces, Shear Forces, Torsion, Beam Stresses.

*D.Static Method*

- Analysis based on state-of-the-art Matrix
- Rafter, Column, Tapered Sections, Rigid Frames, Purlins, Eave Hight.
- Full/Partial Moment Releases.
- Member Offset Specification.
- Fixed, Pinned and Spring Supports with Releases. Also inclined Supports.
- Automatic Spring Support Generator.
- P-Delta Analysis, Non-Linear Analysis with automatic load and stiffness correction. Multiple Analyses within same run.
- Active/Inactive Members for Load-Dependent structures.
- Tension-only members and compression-only members, Multi-linear spring supports.

*E.Dynamic / Seismic Analysis*

- Mass modeling, Extraction of Frequency and Mode shapes.
- Response Spectrum, Time History Analysis.
- Modal Damping Ratio for Individual Models.
- Harmonic Load Generator.
- Combination of Dynamic forces with Static loading for subsequent design.

*F.Secondary Analysis*

- Forces and Displacements at sections between nodes.
- .Maximum and Minimum force Envelopes.
- Load Types and Load Generation:
- Loading for Joints, Members/Elements including Concentrated, Uniform, Linear, Trapezoidal, Temperature, Strain, Support Displacement, Prestressed and Fixed-end Loads.
- Global, Local and Projected Loading Directions.

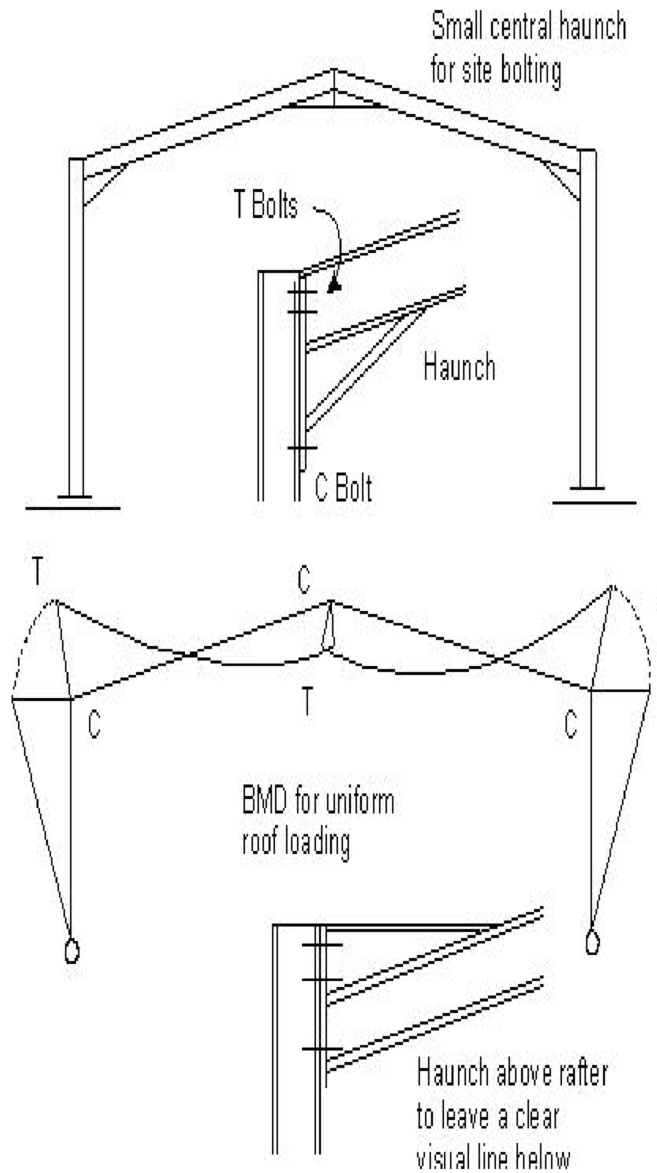
- Uniform or varying Element Pressure Loading on entire or selected portion of elements.
- Floor/Area Load converts load-per-area to member loads based on one-way or two-way actions.
- Automatic Moving Load Generation as per standard AASHTO or user-defined loading.
- UBC 1997.AIJ/IS 1893/Cypriot Seismic Load Generation.
- Automatic Wind Load Generation

Planning of the PEB buildings (low rise metal buildings and arranging different building components is a very important step for the designer before proceeding with the design of each component.

The Following building configurations are significantly affecting the building Stability and Cost:-

- Main Frame configuration (orientation, type, roof slope , eave height)
- Roof purlins spacing
- wall girts (connection & spacing)
- End wall system
- Expansion joints
- Bay spacing
- Bracing systems arrangement
- Mezzanine floor beams/columns (orientation & spacing)
- Crane systems

Some of the above configurations are generally optimised of Pre Engineered Building are outlined. Columns, Rafters, Frames, (Hot Rolled/Built up Sections) Secondary Members – Bracings, Purlins, Girts, (Cold Formed Sections) Roof & Wall Cladding. Figures are given below which gives the idea of the proposed structure:




**Fig; 2. Detailing for Haunch**

Roofing, Cladding, Sand witched Panels, Flashings (Ridge, Gutter etc,.

*Main Frame Configuration*

The various types of Main frame for the basic supporting component in the PEB systems; main frames provide the vertical support for the whole building plus providing the lateral stability for the building in its direction while lateral stability in the other direction is usually achieved by a bracing system. The width of the building is defined as the out-to-out dimensions of girts/eave struts and these extents define the side wall steel lines. Eave height is the height measured from bottom of the column base plate to top of the eave strut. Rigid frame members are tapered using built-up sections following the shape of the bending moment diagram. Columns with fixed base are straight. Also the interior columns are always maintained straight.

*Main frame orientation*

ISSN 2250-3153

Building should be oriented in such a way that the length is greater than the width. This will result in more number of lighter frames rather than less number of heavy frames, this also will reduce the wind bracing forces results in lighter bracing systems.

*Main frame types*

There are several types of main frames used in PEB buildings, the choice of the type of main frame to be used is dependent on:-

- Total width of the building.
- The permitted spacing between columns in the transversal direction according to customer requirements and the function of the building.
- The existence of sub structure (RC or masonry)
- The architectural requirements of the customer specially the shape of the gable.
- The type of rain drainage (internal drainage availability).
- Any customer special requirements.

*Building type Primary framing system*

- depth built-up ―I‖ section, with the large depths in areas of higher stress according to the Bending Moment Diagram;
- Secondary structural members (roof purlins, eave struts and wall girts) which are light weight cold-formed ―Z‖ and ―C‖ shaped members or open web steel joists;
-

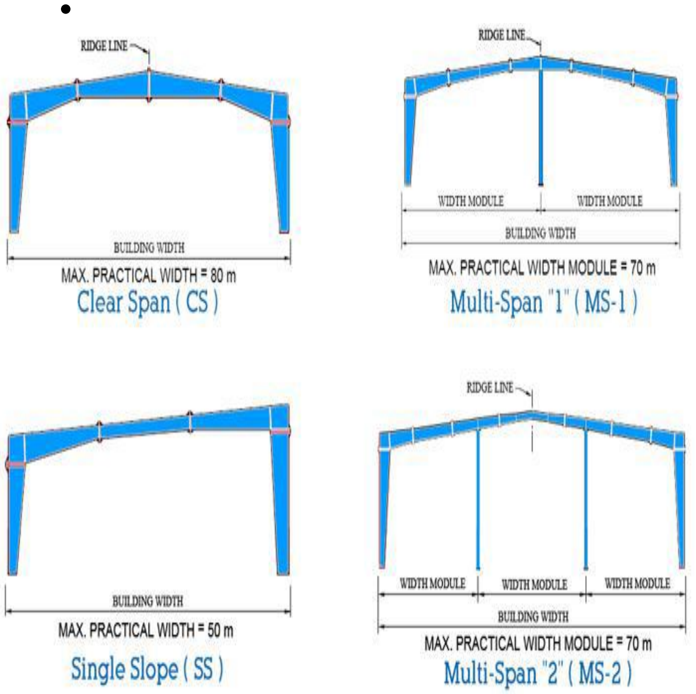



**Fig: 3. Pre Engineered Building types**

- Roll formed profiled sheeting (roof and wall)

The entire primary framing members and secondary structural members are pre-sheared, pre-punched, pre-drilled, pre-welded and pre-formed in the factories before shipping to site for erection are shown in Fig: 3. Quality of building part is assured as buildings are manufactured completely in the factory under controlled conditions. At the job site, the pre-fabricated components are then fixed and jointed with bolt connections. Saving of material on low stress area of the primary framing members makes Pre-engineered Buildings more economical than conventional steel buildings especially for low rise buildings spanning up to 60.0 meters with eave heights up to 30.0 meters. Furthermore, Pre-engineered Building system focuses on using pre-designed connections and pre-determined material stock to design and fabricate the building structures, thus significantly reduces the time for design, fabrication and installation.

Pre-engineered Buildings can be fitted with different structural accessories including mezzanine floors, crane runway beams, roof platform, catwalk and aesthetic features such as canopies, fascia's, interior partitions etc. The buildings are made water proof by use of standing seam roof system, roof drainage components and trims. This is a very versatile building system and can be furnished internally to serve any functions, and accessorized externally to achieve unique and aesthetically pleasing architecture designs, making it ideal for application such as factories, warehouses, workshops, showrooms, supermarket etc.

## IV. Typical Pre-engineered steel structures

The Pre-engineered steel structures shown in Fig: 4 are design for resistant to moisture, adverse weather conditions, earthquakes, termites and fire that provide you with lifelong durability, safety and very low cost-maintenance. Pre-engineered steel building is very simple and economical with the necessary Architectural, Engineering and Construction with pre-engineered steel buildings**.** Assuming that a metal building system is selected for the project at hand, the next milestone is choosing among the available types of pre-engineered primary framing. Proper selection of primary framing, the backbone of metal buildings, goes a long way toward a successful implementation of the design steps to follow. Some of the factors that influence the choice of main framing include:

**Fig: 4. Pre-Engineered Building**

- Dimensions of the building: width, length, and height
- Roof slope

● Required column-free clear spans
● Occupancy of the building and acceptability of exposed steel columns
● Proposed roof and wall materials

The inherent quality of the PEB themselves is a huge contributory factor for this favorable response.

- Reduced construction time.
- Flexibility of Expansion.
- Large Clear Spans
- Low maintenance
- Energy Efficient Roofing and Wall systems
- Architectural Versatility

Most metal buildings are purchased by the private sector, which seems to appreciate the advantages of proprietary pre-engineered buildings more readily than the public entities.

The inherent quality of the PEB themselves is a huge contributory factor for this favourable response.

- Reduced construction time.
- Flexibility of Expansion.
- Large Clear Spans
- Low maintenance
- Energy Efficient Roofing and Wall systems
- Single source Responsibility

## V. CONCLUSION

Choosing steel to design a Pre-engineered steel structures building is to choose a material which offers low cost, strength, durability, design flexibility, adaptability and recyclability. Steel is the basic material that is used in the Materials that are used for Pre-engineered steel building. It negates from regional sources. It also means choosing reliable industrial products which come in a huge range of shapes and colours; it means rapid site installation and less energy consumption. It means choosing to commit to the principles of sustainability. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development.

## ACKNOWLEDGEMENT

We would like to express our deepest appreciation to all those who provided me the possibility to complete this presentation. A special gratitude we give to our faculty, Ms.Sreemanthrapuri, whose contribution in stimulating suggestions and encouragement, helped us to coordinate especially in writing this paper.

## REFERENCES

[1] Ley, J. An environmental and material flow analysis of the UK steel construction sector,Doctor of Engineering thesis, University of Wales, 2003.

[2] Hicks, S. J., Lawson, R. M., Rackham, J. W. And Fordham, P. Comparative structure cost of modern commercial buildings (second edition), The Steel Construction Institute, 2004.

[3] Building Information Modeling.
http://www.laiserin.com

[4] Metal Builders Manufacturing Association http://www.mbma.com/

[5] Introduction to Pre Engineered Buildings, Gursharan Singh, 2008. http://www.engineeringcivil.com/pre-engineered-buildings.html

[6] Automated Rule-Based Building Design and Engineering at Robertson Ceco Corporation, Lachmi Khemlani, 2005 http://www/aecbytes.com/buildingthefuture/2005/RCCstudy.html

[7] Practical Mathematical Optimization: An Introduction to Basic Optimization Theory and Classical and New Gradient-Based Algorithms. Jan A. Snyman (2005), Springer Publishing. ISBN 0-387- 24348-8.

[8] Impact of three-dimensional parametric modeling of buildings on productivity in structural engi- neering practice, Rafael Sacks, Ronen Barak

[9] White paper on PT Structural Modeler / SCIA software for Structural Building Information Mod- eling (S-BIM), Dr. Jean-Pierre Rammant, CEO of SCIA International - June 2004. http://www.scia-online.com

## AUTHORS

**First Author** – Anshu Rajput, B.Tech in Civil Engineering, SRM University and rrajput86@gmail.com
**Second Author** – Divyanshu Pandey, B.Tech in Civil Engineering, SRM University and divyanshu.pandey93@gmail.com.